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Mitigation Strategy on Reduction of Greenhouse Gas Emission for the City of Jayapura

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ABSTRACT

This research would determine a strategy on mitigation attempting to reduce green house gas (GHG) emission in the sector of solid waste management in Jayapura, Papua Province, Indonesia. This sector becomes critical issue and concern, since it turns out to be one of human activities contributing to global warming. Calculation of emission level of this sector refers to a method developed by IPCC 2006, using Microsoft Excel template. Emission level of GHG in the sector of domestic solid waste management is 58,048 Gg CO_2eq. Mitigation in this sector is by closing down the open dumping landfill, maximizing controlled landfill and establishing an integrated waste treatment facility at sub district with a high population density

KEYWORDS*: green house gas, emission, mitigation, strategy*

INTRODUCTION

Status of CO_2 gas concentration in the last one month (31 days) according to the publication done by National Oceanic and Atmospheric Administration (NOAA) from Mauna Loa (Hawaii) is 404.70 ppm or 0.0404% of atmospheric volume (December 25, 2016). If it is compared to the measurement conducted in 2006 (383 ppm or about 0.0383%), concentration rate of CO_2 gas is significantly increasing to 2.1 ppm (*part per million*) per year. This rate is considered as the highest compared to the emission rate at the beginning of 1980s which was 1.58 ppm per year and 1990s which was 1.49 ppm per year. This released CO_2 will be partially reabsorbed by sea and land. However, the capability of land and sea in reabsorbing CO_2 does not significantly change, so that it leads to the increasing of CO_2 at atmosphere from time to time [1].

Such issue has led to the occurrence of global warming problem triggering global climate change of which the impact is affecting, such as temperature increase of earth surface, sea level rise (SLR) and triggering the increase of extreme weather event (EWE) frequency that affects the increasing events of multiple hydro-meteorology disaster such as flood, drought, storm and so forth [2]. In order to eliminate the impact caused by global warming, *United Nations Framework Convention Climate Change* (UNFCCC) set out two main strategies, namely adaptation and mitigation [3]. Mitigation is an attempt to prevent the danger caused by climate change, while adaptation refers to self-adjustment on the incurring climate change [4].

Jayapura is the capital city of Papua Province, where waste problem becomes critical issue. A quite high population growth as many as 4.6% turns out to be a challenge for Jayapura Government in the management of solid waste generated by the population every year [5]. A matter which become the critical issue currently is that waste treatment is not only limited to an attempt of service improvement only, but also how to reduce emission of GHG (CH_4, N_2O and CO_2) produced by such waste treatment. Waste contains organic material, such as food, paper, wood, and garden trimming. Once waste depositedd in landfill, microbes begin to consume the carbon in organic material, which causes decomposition. Under the anaerobic conditions prevalent in landfill, the microbes gradually decompose organic matter over time, methane (approximately 50%), carbon dioxide (approximately 50%), and other trace amounts of gaseous compound (< 1%) are generated and form landfill gas [6]. An optimum scenario (i.e. municipal solid waste stream managed as recycling of recoverable materials, 8%; incineration of combustibles, 60%; landfill of non-combustible, 32%) was modeled to represent the future waste management in Bucharest with regard to its relevance toward the potential for GHG reduction [7].

This research aims to determine a strategy in accordance with current condition and the prediction to the future as a reference for Jayapura Government in their attempt to reduce the emission of GHG. In order to reduce the emission of GHG, a calculation on emission status/level is needed in current condition and prediction to the future so that the reduction strategy can be later on determined.

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RESEARCH METHODS

Determination of mitigation strategy in the reduction of GHG emission level by Jayapura Government can be implemented if there has been an identification and prediction on the status of GHG emission. In this research, a method of IPCC Guidelines 2006 using tier 1 approach, where calculation method of emission and absorption is using basic equation and default emission factors or IPCC default values (i.e., emission factors provided in the IPCC guideline) and activity data used partially sourcing from global data or pursuant to result data of studies conducted in Indonesia. Calculation of level and projection of GHG emission is conducted until 2033, adjusting the documents of Jayapura Spatial Plans Year of 2013-2033.

RESULTS AND DISCUSSION

A. Emission Level/Status

Calculation of GHG emission for solid waste management sector are taken from the following 3 main sources: (1) municipal solid waste disposal, (2) biological management of solid waste, and (3) open incineration of solid waste. For municipal solid waste factor, waste management in a condition of Business as Usual (BAU) or without any mitigation attempts can be seen in the following table.

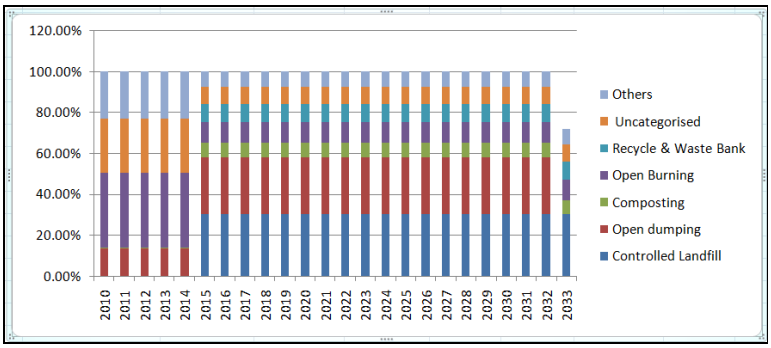
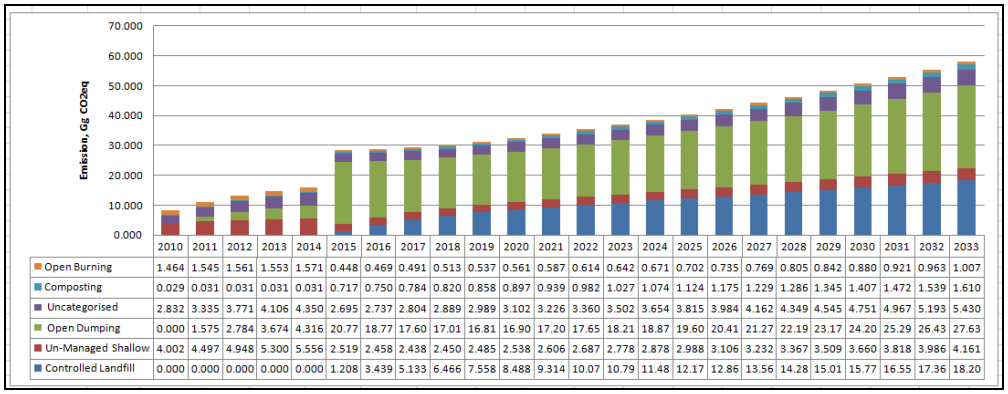


Figure 1. Treatment presentation of solid waste management in BAU Condition

Treatment presentation of solid waste management in the picture above shows that the number of waste transported to controlled landfill is the biggest. At one side, waste management by recycling and waste bank represents that there is an improvement at the end of calculation year. In BAU condition, emission level occurred in 2033 about 58.048 Gg CO_2eq as presented on the following picture.



	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033
Open Burning	1.464	1.545	1.561	1.553	1.571	0.448	0.469	0.491	0.513	0.537	0.561	0.587	0.614	0.642	0.671	0.702	0.735	0.769	0.805	0.842	0.880	0.921	0.963	1.007
Composting	0.029	0.031	0.031	0.031	0.031	0.717	0.750	0.784	0.820	0.858	0.897	0.939	0.982	1.027	1.074	1.124	1.175	1.229	1.286	1.345	1.407	1.472	1.539	1.610
Uncategorised	2.832	3.335	3.771	4.106	4.350	2.695	2.737	2.804	2.889	2.989	3.102	3.226	3.360	3.502	3.654	3.815	3.984	4.162	4.349	4.545	4.751	4.967	5.193	5.430
Open Dumping	0.000	1.575	2.784	3.674	4.316	20.77	18.77	17.60	17.01	16.81	16.90	17.20	17.65	18.21	18.87	19.60	20.41	21.27	22.19	23.17	24.20	25.29	26.43	27.63
Un-Managed Shallow	4.002	4.497	4.948	5.300	5.556	2.519	2.458	2.438	2.450	2.485	2.538	2.606	2.687	2.778	2.878	2.988	3.106	3.232	3.367	3.509	3.660	3.818	3.986	4.161
Controlled Landfill	0.000	0.000	0.000	0.000	0.000	1.208	3.439	5.133	6.466	7.558	8.488	9.314	10.07	10.79	11.48	12.17	12.86	13.56	14.28	15.01	15.77	16.55	17.36	18.20

Figure 2. GHG Emission Level in BAU Condition

From the results in Figure 2, it can be seen that the highest emission is resulted from open dumping i.e., 27,630 Gg CO_2eq or 47.60% from total GHG emission. The type of gas contributing the most to the emission is CH_4 gas with a number of 97.47% from total GHG emission in BAU condition as presented in the following picture. CH_4 gas is the main gas resulted from waste accumulation at landfill and CO_2 is a gas resulted from the process of waste accumulation, composting and fossil carbon open incineration [8]. If the waste at landfill is not managed or reduced, it may lead to the increasing concentration of waste at atmosphere and it will remain for 7 -

10 years so that it will then cause an increase on earth temperature for 1.30° C. This is caused due to to the fact that CH_4 gas has destructive force 21 times worse than CO_2 [9].

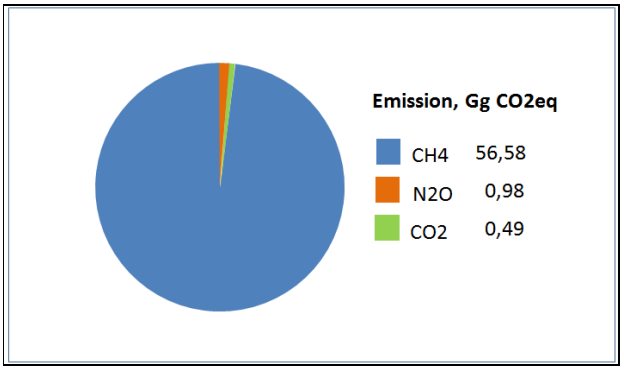


Figure 3. Presentation of gas contributing to GHG emission

B. Emission Reduction Scenario

To reduce emission due to waste accumulation, an intervention on waste sector is required by performing waste treatment innovation so that it may reduce the total amount of waste accumulated at landfills [10]. In this research, the reduction of GHG emission is conducted according to 2 scenarios, where there will be performed a change in the treatment of waste management on each scenario for the purpose to reduce the emission.

Table 1. Scenario of reduction of GHG emission on Domestic Solid Waste

Scenario	Description
Scenario 1	- Closure of open dumping landfills, all waste are accumulated to TPA Controlled Landfill (starting from year of 2019-2033) - Reduction of total amount of carelessly discarded waste - Reduction of total amount of waste burnt using open incineration.
Scenario 2	- Reduction of total amount of waste to TPA Controlled Landfill (starting from year of 2024-2033); - Waste bank capacity increase, recycling and composting through waste depot establishment on each district and sub district with high population density rate - Reduction of total amount of carelessly discarded waste - Reduction of total amount of waste burnt using open incineration.

Scenario determination is inseparable from the planning of waste treatment arranged in the document of Jayapura Spatial Plans Year of 2013-203. According to the description of scenario in the table above, then in the following picture, it can be seen a change on the treatment of solid waste management for scenario 1.

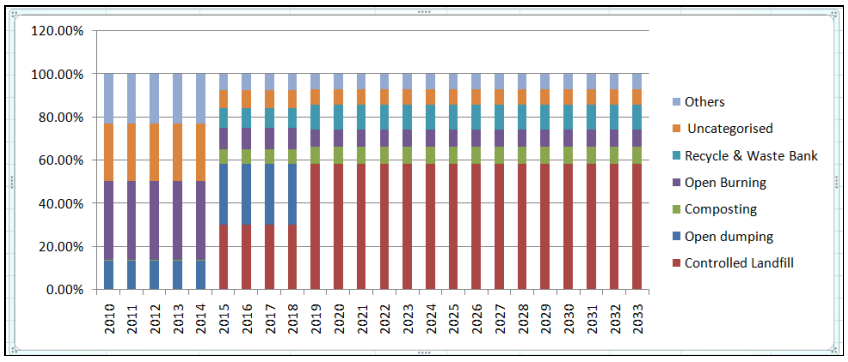
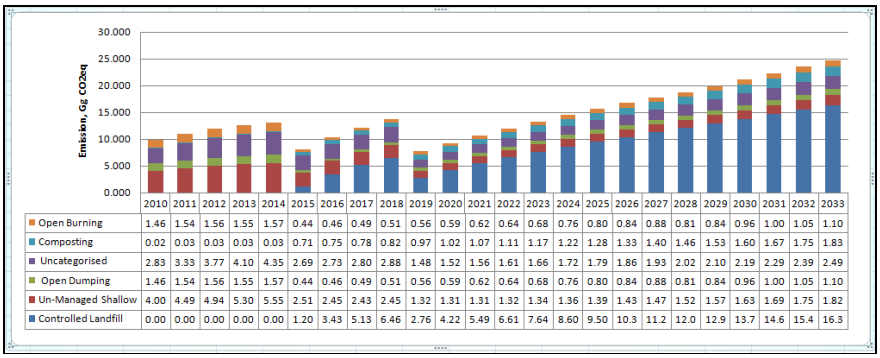


Figure 4. Change on the treatment of waste management on scenario 1

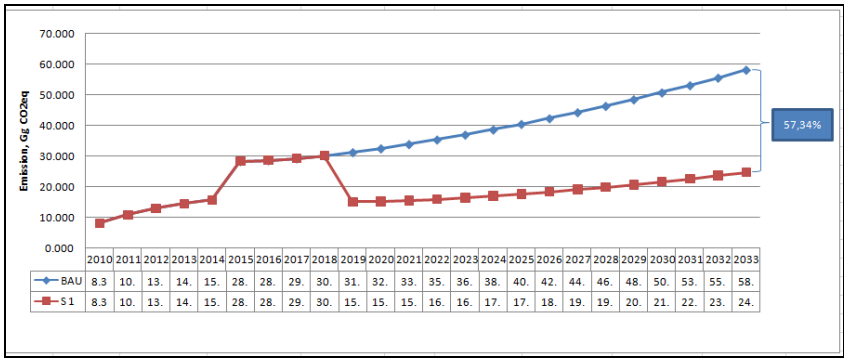
From the change on the treatment of solid waste management in the picture above, then we may see the emission of GHG produced in scenario 1 in the following picture.



	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033
Open Burning	1.46	1.54	1.56	1.55	1.57	0.44	0.46	0.49	0.51	0.56	0.59	0.62	0.64	0.68	0.76	0.80	0.84	0.88	0.81	0.84	0.96	1.00	1.05	1.10
Composting	0.02	0.03	0.03	0.03	0.03	0.71	0.75	0.78	0.82	0.97	1.02	1.07	1.11	1.17	1.22	1.28	1.33	1.40	1.46	1.53	1.60	1.67	1.75	1.83
Uncategorised	2.83	3.33	3.77	4.10	4.35	2.69	2.73	2.80	2.88	1.48	1.52	1.56	1.61	1.66	1.72	1.79	1.86	1.93	2.02	2.10	2.19	2.29	2.39	2.49
Open Dumping	1.46	1.54	1.56	1.55	1.57	0.44	0.46	0.49	0.51	0.56	0.59	0.62	0.64	0.68	0.76	0.80	0.84	0.88	0.81	0.84	0.96	1.00	1.05	1.10
Un-Managed Shallow	4.00	4.49	4.94	5.30	5.55	2.51	2.45	2.43	2.45	1.32	1.31	1.31	1.32	1.34	1.36	1.39	1.43	1.47	1.52	1.57	1.63	1.69	1.75	1.82
Controlled Landfill	0.00	0.00	0.00	0.00	0.00	1.20	3.43	5.13	6.46	2.76	4.22	5.49	6.61	7.64	8.60	9.50	10.3	11.2	12.0	12.9	13.7	14.6	15.4	16.3

Figure 5. GHG emission on scenario 1

It can be seen that after the closure of landfill in open dumping system, the emission in 2033 shows a significant decrease 95.87%. The result is followed with emission decrease in uncategorized which is 54%, landfill using controlled system is 10.2% and unmanaged shallow at the number of 56.15%. Meanwhile, open burning (incineration) shows an increase of 2.6% even though the decrease has been attempted through a change on the treatment, but its emission calculation is done based on the growth of population so that the emission keeps increasing. For a treatment using composting, the emission shows an increase of 12.3% caused by the implementation of methane gas utilization which has not been done yet in this process. Generally, the emission of GHG that can be reduced according to scenario 1 is 57.34% as presented in the following picture.



	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033
BAU	8.3	10.	13.	14.	15.	28.	28.	29.	30.	31.	32.	33.	35.	36.	38.	40.	42.	44.	46.	48.	50.	53.	55.	58.
S1	8.3	10.	13.	14.	15.	28.	28.	29.	30.	15.	15.	15.	16.	16.	17.	17.	18.	19.	19.	20.	21.	22.	23.	24.

Figure 6. The difference of GHG emission in BAU condition and scenario 1.

For scenario 2, the change on the treatment of waste management can be seen in the following picture.

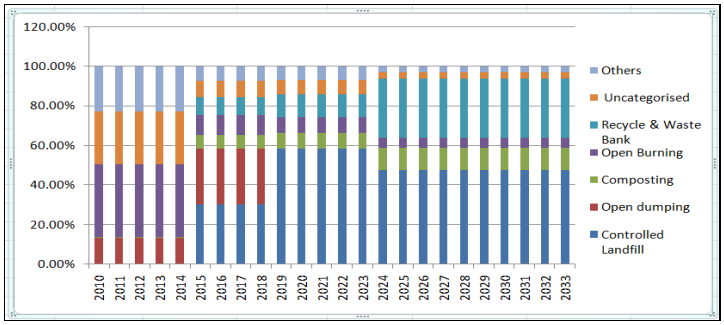
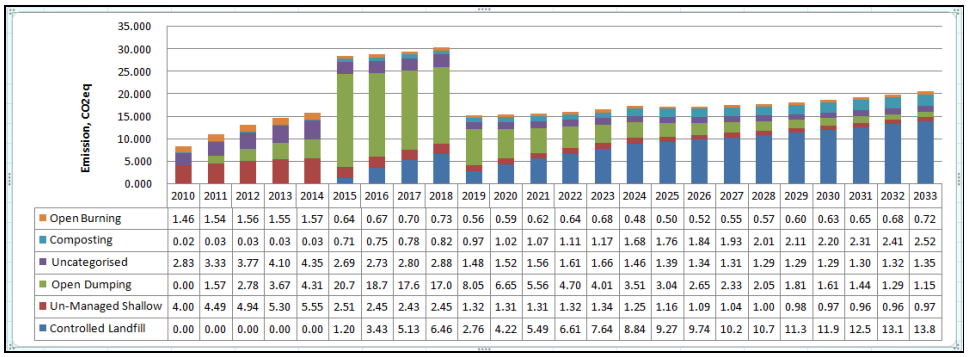


Figure 7. Change on the Treatment of Solid Waste Management (scenario 2)

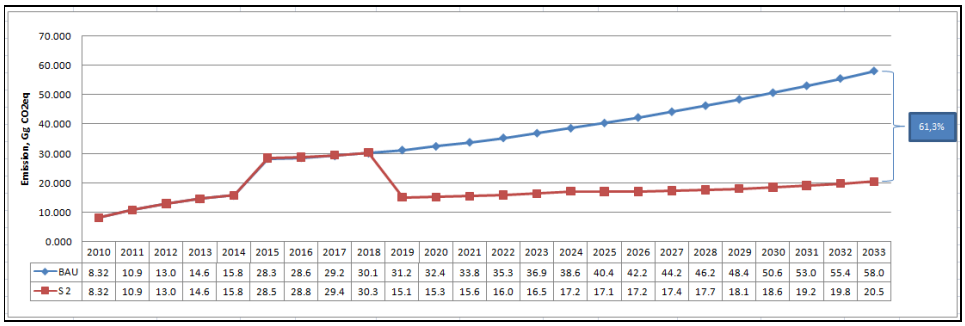
According to the change on the treatment of solid waste management on scenario 2 in the picture above, we may see the emission of GHG which can be reduced in the following picture.



	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033
Open Burning	1.46	1.54	1.56	1.55	1.57	0.64	0.67	0.70	0.73	0.56	0.59	0.62	0.64	0.68	0.48	0.50	0.52	0.55	0.57	0.60	0.63	0.65	0.68	0.72
Composting	0.02	0.03	0.03	0.03	0.03	0.71	0.75	0.78	0.82	0.97	1.02	1.07	1.11	1.17	1.68	1.76	1.84	1.93	2.01	2.11	2.20	2.31	2.41	2.52
Uncategorised	2.83	3.33	3.77	4.10	4.35	2.69	2.73	2.80	2.88	1.48	1.52	1.56	1.61	1.66	1.46	1.39	1.34	1.31	1.29	1.29	1.29	1.30	1.32	1.35
Open Dumping	0.00	1.57	2.78	3.67	4.31	20.7	18.7	17.6	17.0	8.05	6.65	5.56	4.70	4.01	3.51	3.04	2.65	2.33	2.05	1.81	1.61	1.44	1.29	1.15
Un-Managed Shallow	4.00	4.49	4.94	5.30	5.55	2.51	2.45	2.43	2.45	1.32	1.31	1.31	1.32	1.34	1.25	1.16	1.09	1.04	1.00	0.98	0.97	0.96	0.96	0.97
Controlled Landfill	0.00	0.00	0.00	0.00	0.00	1.20	3.43	5.13	6.46	2.76	4.22	5.49	6.61	7.64	8.84	9.27	9.74	10.2	10.7	11.3	11.9	12.5	13.1	13.8

Figure 8. GHG emission on scenario 2.

In scenario 2, according to the treatment of waste management, the emission of GHG that can be reduced, respectively, are open dumping at the number of 95.81%, landfill using controlled system at 24%, uncategorized 75%, unmanaged shallow 76.7%, and open burning at 28.5%. An addition to the number of waste depot at densely populated district and sub district can reduce the total amount of waste accumulated to the controlled landfill, and the same thing goes to uncategorized, unmanaged shallow, and open burning which also show such reduction. Meanwhile, for a treatment of waste management using composting, the emission keeps increasing which is caused by the implementation of methane gas utilization which has not been done yet in this process. Generally, the emission of GHG that can be reduced according to scenario 1 is as many as 61.3% as presented in the following picture.



	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033
BAU	8.32	10.9	13.0	14.6	15.8	28.3	28.6	29.2	30.1	31.2	32.4	33.8	35.3	36.9	38.6	40.4	42.2	44.2	46.2	48.4	50.6	53.0	55.4	58.0
S2	8.32	10.9	13.0	14.6	15.8	28.5	28.8	29.4	30.3	15.1	15.3	15.6	16.0	16.5	17.2	17.1	17.2	17.4	17.7	18.1	18.6	19.2	19.8	20.5

Figure 9. The difference of GHG emission in BAU condition and scenario 2.

C. Emission Reduction Strategy

According to the scenario of emission reduction, several mitigation strategies that can be implemented to reduce the emission of GHG at the sector of domestic waste management in Jayapura city are (1) open dumping closure, (2) reduction of the total number of waste accumulated to controlled landfill, (3) increasing the number of waste depot at densely populated district and sub district, (4) reduction on the total number of carelessly discarded waste, and (5) reduction of open incineration of waste.

CONCLUSION

An addition to the number of waste depot is considered as the core strategy so that other strategies can be effectively implemented. Waste depots is a facility to conduct waste sorting for 3R (Reuse, Recycle, and Reduce) objectives and composting process which directly is able to reduce the total amount of waste accumulated in controlled landfill. Eliminating habit of carelessly discarding waste (unmanaged shallow) and open burning is taken into account as important attempts which shall be done through socialization on society awareness. Reduction of GHG emission according to scenario 1 is 61.3% and scenario 2 is 57.34%. This quite high emission reduction is mainly caused by the closure of landfill with open dumping system.

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